Evidence for an unconformity within the Interior Layered Deposit of Hebes Chasma, Valles Marineris, Mars.
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Introduction: The formation of Valles Marineris (VM) is known to involve a process of collapse combined with slight amounts of extension [1], followed by erosion. Isolated ancestral basins [2] were later linked by further extension [3]. Hebes Chasma (314 km long, 126 km wide, and >8 km deep) is unique to VM in that unlike other chasmata, it has remained isolated and lacks an outwash channel. Interior Layered Deposits (ILDs) are widespread within VM and several processes have been proposed for their deposition [refs in 4]. Examination of layer thickness and attitudes of ILDs within Hebes Chasma help to define their history. This study focuses on the contact between the central ILD mound and a separate ILD located in the eastern portion of the chasm, referred to as the Upper and Lower ILD formations respectively.

Hebes Chasma ILD: Hebes Chasma (Fig. 1A) contains an ILD mound that is 120 km long and 43 km wide. It ranges in elevation from -2,011 m to 3,822 m when measured from the northern floor. A separate ILD located east of the main mound ranges in elevation from -3,925 m to -1,302 m. Its shape is less defined than the mound and measures 40 km across.

Methodology: A CTX mosaic registered to a HRSC composite DTM (orbits 5142, 5160, 5178) formed the base data for the study. Multiple HiRISE and CTX DTMs were calculated with the NASA Ames Stereo Pipeline [4, 5]. Layer attitudes and thicknesses were measured using four HiRISE stereo pairs and seven other HiRISE images registered to a CTX DTM (Fig. 1B). Layer thicknesses were obtained measuring the number of layers along transects and calculating the median thickness for each transect. CRISM data sets within the Upper and Lower ILD formations were analyzed, adding mineralogical information.

Results: The horizontal contact between the Upper and Lower ILD is interpreted as an unconformity (Fig. 1E). Layers within the Upper ILD dip outward around the mound with dips < 10˚. Layer attitudes measured in the Lower ILD display complicated layer orientations with multiple changes in dip direction throughout the formation. The Lower ILD also displays deformation features including faults and open folds.

Layer thickness measurements within the 11 HiRISE images cover a significant range of elevations (Fig. 1F). HiRISE images H1-H7 of the Upper ILD (Fig. 1B) cover a nearly continuous range of elevations from -1,140 m to 3,680 m. HiRISE images H8-H11 of the Lower ILD (Fig. 1B) cover elevations from -1,552 m -3,302 m.

658 layer thicknesses were measured along 82 transects. Elevations of measured layers within the central mound overlap frequently (Fig. 1F). Upper ILD layers range in thicknesses from 0.13 m to 13.39 m with an average of 2.38 m. Lower ILD layers range in thickness from 100.12 m to 0.76 m with an average of 28.09 m.

Analysis of CRISM data shows differing mineral compositions between the Upper and Lower ILD. The Upper ILD contains large amounts of both monohydrated and polyhydrated sulfates, partially covered by mafic minerals (Fig. 1E). The composition of the Lower ILD is more complicated and additional signatures of Fe:Mg-rich phyllosilicates and gypsum are also observed (Fig. 1E).

Discussion: The layer thickness data covers approximately 8 km of stratigraphy. Layer thickness between the Upper and Lower ILD varies significantly.

The layers measured in the Lower ILD are approximately 3 km lower in absolute elevation than the Upper ILD and are significantly thicker than layers of the main mound. Their attitudes do not follow the general pattern of dipping in the direction of slope. Instead the ILD contains open folds, likely as a result of sediment draping upon pre-existing topographical relief on the chasma floor region. Some areas also display faulting. Layer attitudes taken above and below the contact differ. Layers below the unconformity dip due east (Fig. 1D). Layers above the contact dip to the south (Fig.1 C).

Differences in layer attitudes, layer thickness, and mineralogy above and below the unconformity are evidence of two separate and distinct deposition episodes of ILD within Hebes Chasma.

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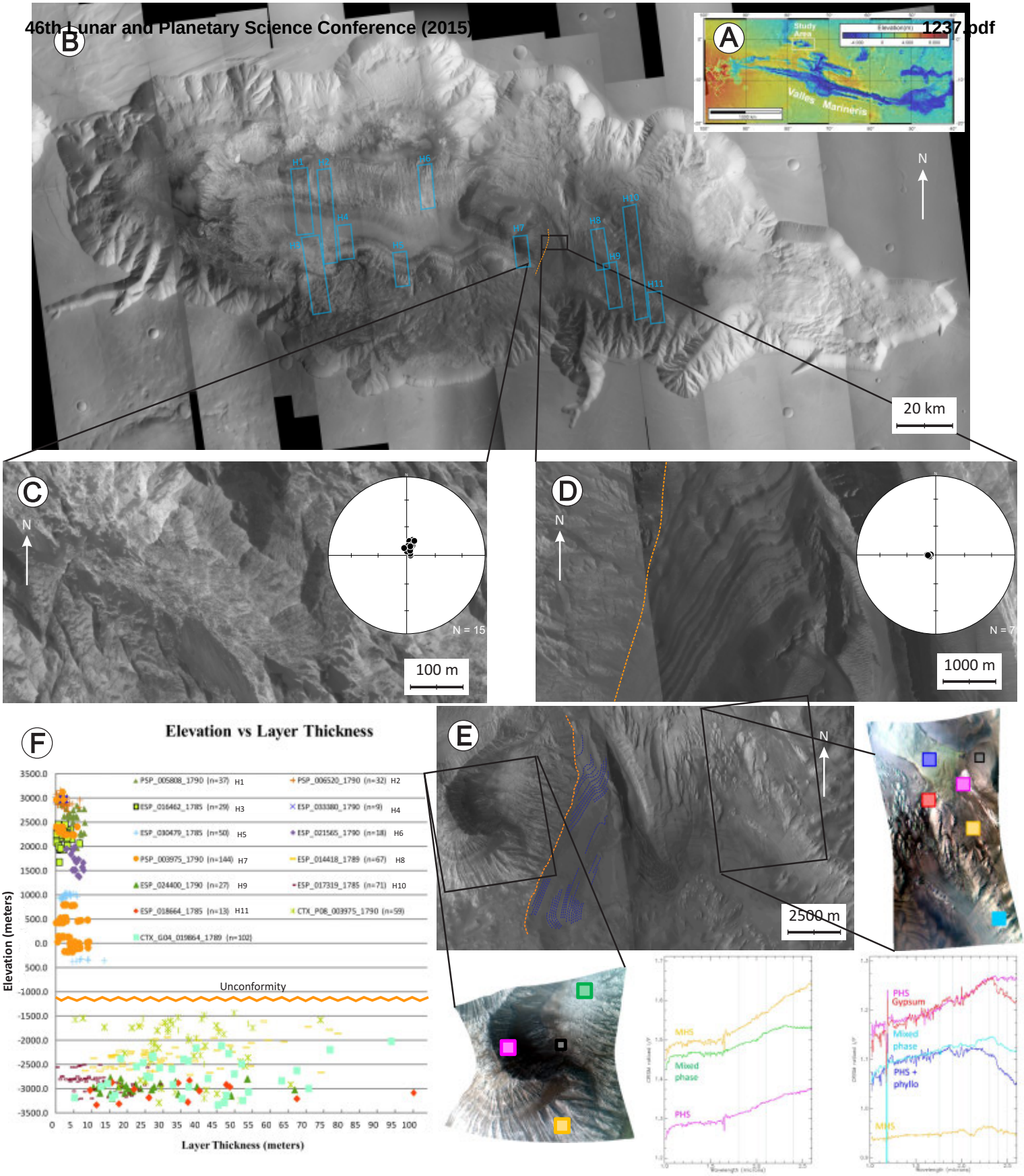

Figure 1: A) Location; B) Hebes Chasma with unconformable contact between Upper and Lower ILD traced by orange line. Location of HiRISE images outlined in light blue; C) HiRISE image PSP_003975_1790 with layer attitudes plotted on stereonet; D) CTX image P08_003975_1790 with layer attitudes plotted on stereonet. Orange line traces unconformity. Stereonets represent layer attitudes measured from HiRISE and CTX data; E) CTX images P08_003975_1790 and G04_019864_1789, Lower ILD traced with blue lines. CRISM observations and associated ratioed spectra; F) Elevation vs. layer thickness.